

Market Connections Report

Integrated Energy Systems: Productivity and Building Science

Consultant Report

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Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

This document is one of 33 technical attachments to the final report of a larger research effort called *Integrated Energy Systems: Productivity and Building Science Program* (Program) as part of the PIER Program funded by the California Energy Commission (Commission) and managed by the New Buildings Institute.

As the name suggests, it is not individual building components, equipment, or materials that optimize energy efficiency. Instead, energy efficiency is improved through the integrated design, construction, and operation of building systems. The *Integrated Energy Systems: Productivity and Building Science Program* research addressed six areas:

- Productivity and Interior Environments
- Integrated Design of Large Commercial HVAC Systems
- Integrated Design of Small Commercial HVAC Systems
- Integrated Design of Commercial Building Ceiling Systems
- Integrated Design of Residential Ducting & Air Flow Systems
- Outdoor Lighting Baseline Assessment

The Program's final report (Commission publication #P500-03-082) and its attachments are intended to provide a complete record of the objectives, methods, findings and accomplishments of the *Integrated Energy Systems: Productivity and Building Science Program*. The final report and attachments are highly applicable to architects, designers, contractors, building owners and operators, manufacturers, researchers, and the energy efficiency community.

This document—Attachment A-1, “Market Connection Report”—provides supplemental information to the final report. It summarizes the market activities, connections and influences of the PIER program.

The Buildings Program Area within the Public Interest Energy Research (PIER) Program produced these documents as part of a multi-project programmatic contract (#400-99-413). The Buildings Program includes new and existing buildings in both the residential and the non-residential sectors. The program seeks to decrease building energy use through research that will develop or improve energy efficient technologies, strategies, tools, and building performance evaluation methods.

For other reports produced within this contract or to obtain more information on the PIER

Program, please visit www.energy.ca.gov/pier/buildings or contact the Commission's Publications Unit at 916-654-5200. All reports, guidelines and attachments are also publicly available at www.newbuildings.org/pier.

Abstract

The Market Connection Report is a product of the *Integrated Energy Systems: Productivity and Building Science* research program, funded by the California Energy Commission's Public Interest Energy Research (PIER) program. This report describes how the program team introduced its research results to key market segments, including manufacturers, California utilities, architects, building system and equipment designers, property owners and managers, and others. Significant market impact occurred in six primary areas:

- *Codes and standards development.* The project's findings informed proposals for California's 2005 Title 24 Standards and contributed to the standards development efforts of building industry organizations.
- *National building industry programs.* The project team joined forces with national organizations to accelerate the adoption of PIER results, including working with the Consortium for Energy Efficiency (CEE) to lay the foundation for developing a national specification for small commercial packaged HVAC systems. Many results are also incorporated in the New Buildings Institute's Advanced Building Guidelines.
- *California utilities.* The project team delivered PIER research results to the California utilities and their customers, and facilitated integration of the results into utility efficiency programs.
- *Presentations and trainings.* PIER methodologies and findings were presented at more than 30 conferences and industry events.
- *Publications.* PIER results were published in about 30 articles, papers and websites in key market areas, as well as in the program's marketing brochures and website.
- *Networking and collaboration.* The project team collaborated with a variety of industry partners to gain acceptance of PIER results in the marketplace.

Author: Cathy Higgins, New Buildings Institute

Keywords: productivity, energy efficiency, indoor environment, daylight, skylight, outdoor lighting, integrated design, HVAC, residential duct

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Executive Summary

The *Integrated Energy Systems—Productivity and Building Science* program consisted of six research elements designed to fill gaps in the existing body of building science knowledge, and address topics that have long been recognized as having untapped potential to save energy, improve indoor environments, and reduce building operating and maintenance costs.

The six program research elements were: 1) *Productivity and Interior Environments*, 2) *Integrated Design of Large Commercial HVAC Systems*, 3) *Integrated Design of Small Commercial HVAC Systems*, 4) *Integrated Design of Commercial Building Ceiling Systems*, 5) *Integrated Design of Residential Ducting and Air Flow Systems*, and 6) *California Outdoor Lighting Baseline Assessment*.

The program resulted in numerous products that will have a significant effect on building industry practices in California and other regions of the United States. Throughout the three-year contract term, the project team—the six research elements as well as an administrative/market connections element—took steps to introduce the research results to key market segments, including manufacturers, California utilities, architects, building system and equipment designers, property owners and managers, and others.

This PIER program had a significant market impact in six primary areas:

- **Codes and standards development.** Five of the research elements played an important role in informing proposals for the 2005 Title 24 Standards. In addition, the program contributed research findings to the standards development efforts of industry organizations such as American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Illuminating Engineering Society of North America (IESNA) and National Fenestration Rating Council (NFRC).
- **National building industry programs.** The project team joined forces with national organizations to accelerate the adoption of PIER results. Team members worked with the Consortium for Energy Efficiency (CEE) and the Air-Conditioning and Refrigeration Institute (ARI) to lay the foundation for the development of a new national specification for small commercial packaged HVAC systems. In addition, many of the PIER research results are incorporated in the *Advanced Building Guidelines* developed by the Institute that are a national guideline on advanced efficiency practices and will be a basis for a new special publication by ASHRAE.
- **California utilities.** The project team worked with California utilities to deliver PIER research results to their account services representatives, customers, and building design professionals, and to facilitate integration into utility efficiency programs. PIER results are used in at least one Energy Design Resources Brief for the statewide Savings by Design Program and have been highlighted in utility outreach to the design community.

Five of the research elements played an important role in informing proposals for the 2005 Title 24 Standards

- **Presentations and trainings.** The project team presented PIER goals, methodologies and findings at more than 35 conferences and industry events around the country. The Pacific Energy Center hosted four trainings based on the PIER results targeted to the architecture and design community.
- **Publications.** PIER results were published in over 30 articles, papers and websites in key market areas. In addition, the Institute created marketing brochures for each research element and developed a New Buildings Institute–PIER public website to disseminate reports, guidelines and other PIER products.
- **Networking and collaboration.** The project team actively collaborated and networked with a variety of industry partners—including manufacturers, building industry professionals and organizations, government agencies, and other researchers—to gain acceptance and application of PIER results in the marketplace.

Introduction: Connecting Research to the Marketplace

The *Integrated Energy Systems—Productivity and Building Science* program consisted of six research elements and one administrative and market connection element designed to fill gaps in the existing body of building science knowledge, and address topics that have long been recognized as having untapped potential to save energy, improve indoor environments, and reduce building operating and maintenance costs.

A major focus of the program was developing connections to pave the way for market adoption of the program's research results. In many cases, the program made discreet and new market impacts that can be solely attributed to this PIER-funded research. In other cases, the PIER research contributed to, or leveraged, existing activities funded by other parties that increased the market influence of the research.

Paving the way for market adoption of the program's research results

This PIER program had significant market impacts in six primary areas:

- Codes and standards development
- National building industry programs
- California utilities
- Presentations and trainings
- Publications
- Networking and collaboration

Results in each of these categories of market connections are discussed later in this report.

Summary of PIER Final Products

Actual research results are described in detail in this program's Final Report, which can be downloaded from www.newbuildings.org/pier or at www.energy.ca.gov/pier/buildings. To set the context for this Market Connections report, a brief summary of the program's key results and products follows:

Element 2 (E2)—Productivity and Interior Environments

Led by Lisa Heschong, Heschong Mahone Group

- *Daylighting in Schools (Reanalysis Report)*. Validated the findings of a previous study of daylighting in schools. Determined that elementary school students in classrooms with the most daylight showed a 21% improvement in learning rates compared to students in classrooms with the least daylight.
- *Daylighting and Retail Sales (Replication Study)*. Found a mean predicted effect of a 0%–6% increase in sales for an average daylit store compared to a non-daylit store.
- *Healthy Schools: Daylighting, Lighting and Ventilation*. Did not find a correlation between classroom daylight conditions and student learning rates. Found that ample and pleasant views out of classroom windows have a positive effect on student learning. Sources of glare, as well as acoustic problems related to classroom design, have measurable negative effects on learning rates.
- *Healthy Offices: Daylighting, Lighting and Ventilation*. Concluded that daylight illumination levels were significant and positive in predicting better performance on a test of mental function and attention, but daylight was not found to improve performance on visual acuity tests measured on computer monitors. Ample and pleasant views was consistently associated with better office worker performance, and glare from windows was associated with decreased worker performance.

Element 3 (E3)—Integrated Design of Large Commercial HVAC Systems

Led by Erik Kolderup, Eley Associates, Inc.

- *Advanced VAV System Design Guide*. This Design Guide was written for HVAC designers and focuses on built-up variable-air-volume (VAV) systems in multi-story commercial office buildings in California. The recommendations address airside system design, covering fans, air handlers, ducts, terminal units, diffusers, and their controls, with emphasis on the integrated design and performance of the air distribution system components. The Design Guide promotes efficient, practical designs that advance standard practice and can be implemented successfully today.

Element 4 (E4)—Integrated Design of Small Commercial HVAC Systems

Led by Pete Jacobs, Architectural Energy Corp.

- *Design Guidelines*. These comprehensive Design Guidelines focus on actions architects, engineers, and design/build contractors can take to improve the energy

efficiency of small package HVAC systems, reduce operating costs, and improve indoor comfort and environmental quality.

- *CEE HECAC Collaboration.* E4 and the Institute collaborated with the Consortium for Energy Efficiency (CEE) and their High Efficiency Commercial Air Conditioning Committee (HECAC) to develop a national, next-generation performance specification for small commercial, integrated rooftop HVAC systems. The specification is drafted into various phases for adoption now by utility and public benefits organization and a later phase aligned with development of new advanced equipment.

Element 5 (E5)—Integrated Design of Commercial Building Ceiling Systems

Led by Jon McHugh, Heschong Mahone Group

- *Design Guidelines for Skylights with Suspended Ceilings.* This document provides information and guidelines for ceiling-component and skylight manufacturers, designers and contractors to assist them in developing modular skylight/light-well systems for suspended ceilings.
- *Comprehensive Skylight Testing and Photometrics.* E5 developed test protocols and conducted tests on various skylight and light-well combinations common in commercial construction. There were three separate sets of testing activities for U-factor, SHGC and visible transmittance. The team also developed photometric data for nine skylights with different light-well geometries. This data, which is now publicly available, provides lighting designers with new predictive tools for designing with skylights.

Element 6 (E6)—Integrated Design of Residential Ducting and Airflow Systems

Led by Roger Hedrick, GARD Analytics

- *Home Builders Guide to Ducts in Conditioned Space.* This construction guide describes for builders ways to modify home designs to incorporate the recommended approaches to putting ducts inside conditioned space. It describes construction techniques, provides technical diagrams, addresses market barriers, and gives summarized cost and savings information.
- *Technical Information Package—Code Officials and Consumers.* This provides technical information that builders can present to code officials when requesting a variance to build a house that follows one of the recommended approaches to putting ducts in conditioned space. There is also a brief marketing tri-fold for homeowners that promotes the benefits of placing ducts in conditioned space.
- *Technical Information Report.* This document, intended for the Commission and technical audiences, summarizes the recommended approaches to putting ducts in conditioned space and describes associated costs and savings.

Element 7 (E7)—Outdoor Lighting Baseline Assessment

Led by Matt Brost, RLW Analytics

- *California Outdoor Lighting Baseline Assessment.* This groundbreaking study of outdoor lighting practices and energy use in California provides a wealth of data, offers important lessons learned during the research project, and lays out a rigorous methodology that can be used by researchers intending to conduct additional studies of outdoor lighting.

Codes and Standards

KEY ACHIEVEMENTS

The New Buildings Institute's PIER Program made important contributions to the development of the California 2005 Title 24 Standards. E4's field findings, for example, informed the Nonresidential Acceptance Requirements proposal, while their analysis supported the Nonresidential Duct Sealing and Insulation proposal through PG&E's CASE initiative. E5's photometric and haze studies led to a revised definition of the daylit zone and revised spacing criterion for skylights, which will result in improved daylighting quality. Results from E5's ceiling insulation work are incorporated in the proposal to eliminate the insulation allowance for dropped ceilings. E7's survey results are informing the effort to develop a new outdoor lighting standard. These achievements and others are summarized in Table 1.

...studies led to a revised definition of the daylit zone and revised spacing criterion for skylights.

As well as contributing to the Title 24 proposals, the New Buildings Institute's PIER Program made substantial contributions to proposals for modifications to industry organization standards, including ASHRAE, IESNA and NFRC. See Table 2 for a summary.

Table 1. PIER Contributions to 2005 Title 24 Standards Proposals

Element	PIER Title 24 Involvement
E3	Findings on static pressure reset, sensor location and fan-power sizing modified prescriptive requirements for space conditioning systems (Eley & Associates).
E4	Field findings helped document problems with small commercial package HVAC systems that will be addressed through new Nonresidential Acceptance Requirements and validated the performance of OEM economizers. The proposal recommends establishing Acceptance Requirements for Nonresidential Buildings, which would include inspection checks and functional and performance testing to determine if specific building components, equipment, systems, and interfaces between systems conform to the criteria set forth in the Standards and to related construction documents (plans or specifications) (New Buildings Institute).
	PIER modeling and analysis on field findings supported the Nonresidential Duct Sealing and Insulation proposal (PG&E CASE Initiative).
E5	<p>PIER photometric and haze studies were used in the Title 24 analysis of the daylit area under skylights.</p> <p>The proposed revision to Section 131c addresses the definition of the daylight zone. Based on the PIER photometric testing of skylights, the spacing criterion (SC) would be revised from 2.0 to 1.4. This change affects the number of skylights needed to create a uniform daylit zone within a space.</p> <p>The definition of haze developed during the E5 research was used as one of the criteria to assure that skylights in commercial buildings required diffusion characteristics. The proposal defined a diffusion metric (haze) that would be required for obtaining energy credits for using skylights (Section 146), and would also be prescriptively required in Section 143(c).</p>
	<p>With funding from the Commission, the research leader drafted a proposed change to Title 24's Section 118—the requirement for placement of roof/ceiling insulation in nonresidential and high-rise residential buildings. As a direct result of PIER Project 5.2's field results and energy and cost analyses, this proposal recommended the elimination of the allowance of insulation on dropped ceilings. This proposal would effectively prohibit lay-in insulation with dropped ceilings except for spaces with plenum heights greater than 12 ft. The proposal encountered little resistance, the Commission staff has supported it, and adoption is anticipated.</p>
E6	<p>Technical data was provided to support future Title 24 code development to place ducts inside conditioned space in residential construction. Data included market barriers and methods for overcoming them; cost/benefit data; and methods for verifying compliance.</p>
	<p>ASHRAE Handbook. E6 provided information on descriptions of alternative duct placement duct leakage that will be included in the updated ASHRAE Systems and Equipment Handbook (Chapter 9, duct design), to be published in 2004.</p>
E7	The PIER Outdoor Lighting Baseline Assessment informed the development of new standards for outdoor lighting.

Table 2. PIER Contributions to Industry Organization Standards Proposals

Element	Organization	Standards Involvement
E1	ASHRAE	The PIER work contributed to the Institute's <i>E-Benchmark</i> TM energy performance criteria within the Institute's "Advanced Building Guidelines". ASHRAE announced in August 2003 that they are developing a new "Special Publication" Advanced Guideline to show how to achieve 30% better than the ASHRAE standard. New Buildings Institute is a sponsor in this effort (along with AIA, IESNA and DOE) and the Advanced Building Guidelines and PIER results will feed into the new ASHRAE guide due out in summer of 2004.
E5	Illuminating Engineers Society of North America (IESNA)	Developed a new method for testing the photometrics of skylights and applied the photometric data to IESNA's LM63-1995 format. This allows for predicting the luminous performance of skylights. A proposal to update the current format to better reference the new skylight-specific information was made to IESNA and is expected to be implemented in the update.
	NFRC	Provided NFRC with U-factor and solar heat gain coefficient (SHGC) testing data and code-related information, emphasizing the need for a non-residential rating of skylights. Potential outcomes: 1) NFRC will modify their rating system for tubular daylighting devices; and 2) U-factor results will affect how NFRC rates skylights. NFRC published E5's presentation on their website.
	Energy Star windows program	Concerns were raised with the EPA program administrator about Energy Star residential approach to the rating of skylights for commercial buildings. This feedback may influence EPA's adoption of a separate commercial skylight rating.
	ASHRAE	Provided information on SHGC and U-factor testing to be used in developing rating systems and improving manufacturing standards. Also, ASHRAE's Subcommittee on Skylights is considering the use of PIER photometric results in the development of future codes.

Application of PIER Results to National Programs

KEY ACHIEVEMENTS

This PIER program focused on conducting research and promoting practices that will improve building performance in California. To achieve market acceptance, however, it is also important to connect PIER research to the national marketplace, in part because major manufacturers are often reluctant to develop products for regional or niche markets. Similarly, codes and standards development has greater penetration potential if based on proven and widely accepted “best practice” design and operation criteria.

The two collaborative programs described below promise to accelerate market acceptance of PIER research and products in California and nationally. These programs will help deliver PIER research results to manufacturers, building owners and developers, architects and engineers, contractors, code and planning officials, and the academic community.

Consortium for Energy Efficiency Initiative

E4 and the Institute collaborated with the Consortium for Energy Efficiency (CEE) and their High Efficiency Commercial Air Conditioning Committee (HECAC) to develop a national, next-generation performance specification for small commercial, integrated rooftop HVAC systems. CEE’s HECAC committee has approved the proposed specification, which integrates findings from E4’s research on small package HVAC system design and performance. CEE is currently working with its members to engage other manufacturers and organizations such as the Air-Conditioning and Refrigeration Institute (ARI) in discussions about the HECAC initiative. This joint venture will broaden the market for technologies identified by the PIER research and provide greater incentives for manufacturers and others to embrace the practices recommended by Element 4.

CEE’s proposed spec integrates findings from E4’s research on small package HVAC systems

The draft specification has 3 Tiers which are described below:

Tier 1: This consists of a set of specs that are all currently available on the market, can be requested today, and are fundamental to improving field efficiency and performance. It is intended as the foundation requirements of an advanced rooftop unit, and provides an immediate basis for utilities to upgrade requirements within their programs.

Tier 2: This incorporates the Tier 1 specs plus additional design features to create a new Advanced Rooftop Unit (ARTU) that delivers greater field efficiency and performance. These features are not readily available on the market, but are a part of a development and testing project underway in the next two years through a new PIER project that includes manufacturer partners.

Tier 3 is a proposed performance-based measurement for future specification development. There is currently a lack of performance-based measures and test protocols to address in-field performance problems that affect efficiency. As a result, the HECAC committee has identified a number of measures that would be useful in shifting the specification towards a performance-based measure.

Advanced Building Guidelines

The *Advanced Building Guidelines* (Guidelines), developed by the New Buildings Institute and a team of nationally recognized experts in building performance, promotes high-performance commercial building construction. The Guidelines establish an influential new set of voluntary commercial building performance criteria. These criteria are published in a document titled “Energy Benchmark for High-Performance Buildings” (*E-Benchmark*™).

The E3 and E4 PIER results contributed to the establishment of the criteria in the mechanical section of the *E-Benchmark*™. Results from E2 and E5 supported criteria in the lighting and envelope sections. *E-Benchmark*™ provides a comprehensive whole-building efficiency target that can be the basis for utilities’ and public-benefit funds’ new construction program requirements. The targets can also serve as a new “reach” standard or code for adoption by independent organizations, private industry or governments. Currently ASHRAE, DOE FEMP, LEED, the California investor-owned utilities (IOUs), and numerous utilities nationally are looking to the Guidelines as a fundamental tool to help achieve their new commercial efficiency objectives.

The Guidelines’ next phase—a Best Practices Manual, Owner’s Guide and training development—will adopt significant content from the E3, E4 and E5 Design Guides. The Best Practices Manual is targeted directly at design teams for new commercial buildings and will incorporate many of the specific technologies, design approaches, guidelines, and research results from these PIER elements.

The 2003 version of *E-Benchmark*™ was published in October 2003 and can be downloaded from the Institute’s website (www.newbuildings.org/ABG.htm) or purchased online from Powell’s Books (www.powells.com).

The Institute worked with the PIER team to review the *E-Benchmark*™ criteria and prepare for the integration of PIER results into the Guidelines’ Best Practices manual, references and training materials, which are scheduled for release throughout 2004. The Institute has kept California utilities informed of the Guidelines’ progress, and many regional and national public benefit groups are supporting the development of this important tool for improved building performance.

The August 2003 announcement by ASHRAE that they will develop a new Special Publication on Advanced Practices was partly spurred by the *E-Benchmark*™ progress and outcomes. The Institute is a co-sponsor of this new national guide and will promote the inclusion of the PIER content into the new ASHRAE guide. Engineers use ASHRAE guides more than any other resource for design assistance.

Transfer of Program Results to California Utilities

KEY ACHIEVEMENTS

The project team worked with California investor-owned utilities to determine effective ways to deliver the PIER findings to utility account representatives and customers and to facilitate integration into utility efficiency programs. Market connections with the utilities occurred on five primary fronts, which are listed below and subsequently described in greater detail.

- **Account Services Support.** Provided briefings, design guides and research findings to account services departments.
- **Business Customer Information.** Provided technical content to the utilities for use in their newsletters and other customer information products and services.
- **Utility Training.** Conducted training sessions for architects, engineers, designers and other industry professionals at various utility training centers.
- **Savings by Design/Energy Design Resources.** Provided technical content based on PIER results to the Savings by Design/Energy Design Resources program.
- **CPUC Local Initiatives.** Worked with administrators of Local Energy Efficiency Initiatives to incorporate PIER design guidelines into their programs

Account Services Support

The Institute met with PG&E, SCE, SMUD and Sempra Utilities (SoCalGas and SDG&E) to deliver concise messages on PIER findings to Account Representatives that are transferable to their Customers. Account Representatives have considerable credibility with customers and can have a powerful influence on new construction and major retrofit decision-making. The utilities are always seeking information that adds value to the interactions between representatives and customers. The Institute developed messages, briefing papers and coordinated with utilities on delivery systems.

Outcome: Most utility commercial account services reps are now familiar with the PIER program results, resources and products. They will use the results to improve their services to commercial new construction customers.

Business Customer Information

To facilitate energy-efficient design in new and major retrofit construction, the utilities agreed to accept feature articles, news items, energy tips, and website links for release through direct communications with customers, such as:

- *E-mail newsletters to business customers.* Although the programs vary by utility, “E-newsletters” are sent to different customer classes, depending on size (small business, large commercial accounts assigned to account representatives, and large commercial accounts that are unassigned), and are also sent to commercial developers.

- *Business association e-mail newsletters.* These are distributed to business associations such as Chambers of Commerce, BOMA, Building Industries Association, and similar organizations for subsequent forwarding to members.
- *Primary websites.* The utilities' primary websites, such as www.pge.com, will include both PIER content and links to a reports repository of PIER Design Guidelines and other reports.

Outcome: E4 findings were included in a PG&E commercial customer newsletter. The Institute is working with all utilities to integrate PIER content and links on their websites, the PIER brochures have been distributed to all utilities, and content on the projects is planned for some newsletters and outreach communications throughout the next year.

Utility Training for Design Professionals on PIER Findings and Design Guides

In 2003, PIER Element Leaders conducted training sessions at PG&E's Pacific Energy Center in San Francisco to share PIER results with design professionals. Other major utilities have been approached about similar trainings, but topics, dates, and locations are yet to be determined.

Table 3. Training Sessions based on PIER Results at Pacific Energy Center

Element	Date	Training Session Title
E2	5/03	Coalition for High Performance Schools (Eley/HMG)
	4/03	Lighting for Schools (HMG)
E2 & E5	3/03	Daylighting Basics for Lighting Designers and Electrical Engineers (HMG)
	11/02	E2 and E5 results presented at general training on skylighting design (HMG)
E3	10/03	Advanced VAV System Design Guideline (Eley)
E4	5/03	Integrated Design of Small Commercial HVAC Systems results and design guidelines (AEC)
E5	6/03	Integrated Skylights and Electric Lighting in Commercial Ceiling Systems (HMG)

Savings By Design/Energy Design Resources

Savings By Design is a statewide new-construction program operated by the investor-owned utilities that provides energy efficiency design assistance directly to commercial customers. *Energy Design Resources* (EDR) is a related, website-based repository of technical information. Both activities are funded by utility-administered public goods charge (PGC) funds. These programs are targeted at building designers (architects, engineers, design-build contractors) and building owners. Table 4 describes the ways PIER is being incorporated into this important California new construction program.

Table 4. Savings by Design/Energy Design Resources Activities

Date	Title	Description
Fall 2003	Savings By Design (SBD)	PIER briefings, results and products to SBD customer technical assistance design and engineering staff.
Fall 2003	Energy Design Resources	PIER E3 and E5 results to EDR publication review committees. Planned “Design Briefs” co-funded with PIER.
March 2003	Energy Design Resources “Design Brief”	PIER E4 results provided the basis for a new EDR Design Brief on “Integrated Design of Small HVAC Systems” that is published on EDR’s website. Other Design Briefs are being considered.

Outcome: Based on presentations by Institute staff along with some research leaders, the SBD staff is now fully aware of the PIER program results, energy saving estimates, and potential for the results and products to help improve their program and customer offerings. The SBD staff is looking at ways to include the PIER Design Guides as a part of their customer and program resources. Customers wanting to access incentives through this program could use the PIER Design Guides as a tool to achieve the SBD required targets.

CPUC Local Initiatives

In 2002, the California Public Utilities Commission (CPUC) selected a number of contractors to administer two-year “Local Energy Efficiency Initiatives” in various parts of the state. These are primarily targeted at small commercial, low-income residential, and “hard-to-reach” customers. The contracts are administered by PG&E, SCE, and SDG&E. The Institute has been involved with the largest of these contracts, the \$6–million Oakland Energy Partnership (OEP).

Outcome: OEP contractors have agreed to incorporate the Small Commercial HVAC Guidelines from PIER Element 4 into their design assistance services portfolio. The Institute will contact other Local Initiatives contractors providing similar services throughout the state to include the same direct, practical application of the PIER guidelines into their programs.

Other Utility-Related Activities

- Element 2 reports that California utilities have expressed interest in funding demonstration projects to help retailers determine how to economically retrofit skylighting into existing stores.
- Element 5 has communicated with California utilities about the possibility of offering incentives to develop modular skylight/light-well systems.

Presentations

KEY ACHIEVEMENTS

The project team gave more than 35 presentations at industry conferences and events around the country (see Table 5). Early in the contract term, these presentations served to introduce the PIER program and its goals to key audiences, to stimulate interest, connect with related activities, and begin paving the way for market acceptance of the research findings. Subsequent presentations were more explicitly focused on delivering specific findings to key professional audiences.

Table 5. PIER Presentations

Element	Forum	Date	Description
E1	CA IOUs	10 & 11/03	Briefings on the PIER results and products with the CA IOU staff.
	California Energy Commission, Sacramento	10/03	Presentation on the program results and impacts to the Commission, PAC members and interested parties.
	CEE/ARI Meeting, Boston	9/03	Presented findings on small package problems and potential solutions to major manufacturers and national market transformation organizations. Lead discussions on developing new specifications.
	SMUD	5/02	Strategy discussion and briefing included PIER.
	PG&E	5/02	Strategy discussion and briefing included PIER.
	BOMA National Conference, Baltimore	6/01	National conference for building owners and managers. Institute presentation at session on Workplace Performance.
	GlobalShop Retail Conf., Chicago	3/01	Major retail industry conference. Emphasized E2, E5 and E7.
	California Energy Commission, Sacramento	11/00	Commission-sponsored PIER presentation to the general public.
E2	Center for the Built Environment, Berkeley	10/03	Key note presenter at the partners meeting on the PIER daylighting in schools research, findings on student performance, building environmental impacts and energy savings potential.
	Lighting and Health workshop,	5/03	Led workshop that included presentation on current and past work (funded through non-

Element	Forum	Date	Description
	Washington, D.C.		PIER sources).
	Local AIA conference, Seattle	5/03	Presented the schools' studies (funded through non-PIER sources).
	FEMP Advanced Lighting Workshop	4/03	Presented current PIER findings to federal energy program managers.
	Coalition for High Performance Schools (CHPS), locations throughout California	2002–2003	CHPS runs training programs for architects and school administrators. There have been about a dozen in recent months. A 15-minute section on the Daylighting study is included. Also, a subchapter in CHPS Vol. I is devoted to the Schools study.
	Emerging Technology Council for California Utilities	12/02	Presented project description and findings.
	ACEEE Summer Study, Monterey, CA	8/02	Two presentations: School findings and discussion roundtable to energy and building scientists.
	LightFair, San Francisco	6/02	Presented school lighting design seminar and School Daylighting Reanalysis results.
	Coalition for Adequate School Housing, Sacramento	2/02	School Daylighting Reanalysis presented to 70 attendees including government, school & building industry representatives.
	IESNA, Ottawa	8/01	Schools study presented to lighting contractors and manufacturers.
E3	ASHRAE Winter meeting, Anaheim	1/04	A seminar (Lessons from the Field) and a symposium (Fan Model) are scheduled on the new fan model developed by E3 researchers.
	ASHRAE chapter meeting, Salt Lake City	3/03	Research results presented by Taylor Engineering (presentation funded separately by the Institute).
	ACEEE Summer Study, Monterey	8/02	Presented a paper, "Measured Performance and Design Guidelines for Large Commercial HVAC Systems."
E4	Consortium for Energy Efficiency (CEE) Quarterly Meeting, Portland	6/03	Participated in discussions on package system performance and economizers. Final approval by the CEE committee on the PIER-based advanced specification.
	National Conference on	5/03	Institute and AEC led discussions on PIER small-package system results and Guidelines,

Element	Forum	Date	Description
	Building Commissioning, Palm Springs		with focus on economizers. Accompanying paper published.
	National Market Transformation Symposium, Boston	4/03	Presentation on package HVAC problems, solutions and the development of a national specification with CEE.
	ASHRAE Winter Meeting, Chicago	1/03	Presentation on E4 results.
	IFMA World Workplace Convention, Toronto	12/02	AEC presentation on providing value to building occupants; included E4 results and recommendations.
	E Source Annual Forum	11/02	Presentation on E4 results.
	ACEEE Summer Study, Monterey	8/02	Institute and AEC conducted session on small-package HVAC problems and a possible national spec; presentation jump-started the CEE collaboration.
E5	NRFC, Annual Meeting, Tucson	6/03	Presentation on U-factor testing and code-related issues. Proposed that NFRC reconsider their rating system for tubular skylights.
	TAG members	2/03	Presentation of findings to major acoustic tile manufacturers (representing 95% of the T-bar market); major retail chain construction representatives; and skylight manufacturers. Presentation also given to lighting software developers.
	SkyCalc training at Edison CTAC, Irwindale, CA	2002–2003	Ongoing SkyCalc training incorporates E5 findings.
	IESNA Annual Conference	8/02	Presented “Skylights as Luminaires: PIER Skylight Photometric Test Results.”
	Pacific Energy Center, San Francisco	6/02	Skylight photometrics presentation to lighting contractors and manufacturers.
	American Association of Manufacturers (AAMA), Tucson	1/02	Presentation on impact of integrated ceiling project on skylight market, use of software to improve skylighting design, and proposed T24 code change proposals.
	ASHRAE Annual Meeting, Kansas	6/03	Discussed draft of PIER Home Builders Design Guide at meeting of the TC 6.3 committee on Central Forced Air and Cooling

Element	Forum	Date	Description
	City		Systems.
	Construction Specification Institute National Conf., Chicago	4/03	Presentation to building industry on Residential Ducting and Airflow Systems.
E7	ACEEE Summer Study, Monterey	8/02	Presentation on PIER “California Outdoor Lighting Baseline Assessment.”
	LightFair, Las Vegas	5/01	Presentation to over 200 lighting industry professionals includes information about the PIER “California Outdoor Lighting Baseline Assessment.”

Publications

KEY ACHIEVEMENTS

Publications are a powerful medium for influencing the construction and design industry, as evidenced by a recent survey by the Northwest Energy Efficiency Alliance, which found that the top places architects turn to for information are professional journals and magazines. To get the attention of the market players most likely to benefit from the PIER results, the project team targeted key industry publications, and published its results in over 30 articles, papers and websites, as listed in Table 9 at the end of this section.

For example, *HPAC Engineering*, a magazine serving the heating, plumbing and air-conditioning industries, published five PIER articles (one on E3's fan model and four on E4's small package systems project) that reached more than 4,000 California design and engineering professionals. Table 6 and Table 7 show that *HPAC's* audience is highly matched to the PIER objectives of new construction decision-makers for mechanical systems.

This excerpt from an email about the E3 article forwarded to us by the editor at *HPAC Engineering* provides rewarding feedback on the value of our publishing efforts:

“Last month’s article on fans was excellent. I used it yesterday to help explain a control static set point problem on a VAV system while at the job site...”

“Last month’s article on fans was excellent. I used it yesterday to help explain a control static set point problem on a VAV system while at the job site. The owner, consulting engineer, controls engineer and others were all present. For you, Mike and everyone at HPAC, keep up the good work!”

—Jeff S. Forman, Marketing Manager, Temtrol, Inc.

Table 6. HPAC Engineering’s California Subscribers by Profession

Profession	Total	Eng. Mgmt	Staff Eng.
Consulting Engineer/Arch Firm	1,270	738	532
Engineering/Construction Firm	357	239	118
Design/Build or Mechanical Contractor Firms	466	328	138
Industrial/Processing/Mfg Firms	754	507	247
Commercial/Institutional/Government Firms	1,232	801	431
Total	4,079	2,613	1,466

Table 7. HPAC Engineering's California Subscribers: Mechanical System Decision-Makers

Table shows that 92% of California subscribers responded that they “personally specify, design, recommend, and/or make product selections for mechanical systems components in new or existing buildings”.

Response	Total	Percent	Eng. Mngmt	Staff Eng.
Yes	3,764	92.3%	2,416	1,348
No	268	6.6%	160	108
No Answer	47	1.2%	37	10
Total	4,079	100%	2,613	1,466

Other Significant Publication Activities

- *Marketing brochures.* The Institute created brochures for each research element that target their specific market areas and promote their research results and products.
- *Website.* Web access and dissemination of information is fast overtaking other traditional methods of communications. The Institute hosts PIER results and products from both its home page and a public page dedicated just to PIER. The Institute has also sent out e-notices to interested parties following the completion of the two early PIER reports: “Outdoor Lighting Baseline Assessment” and “Daylighting in Schools: Reanalysis Report.” The Institute also notified parties of the availability of E5’s skylight photometric files. A few other PIER reports have been placed on the PIER public site. The following statistics show the extent of online access to date:
 - ♦ In the last 12 months, the Institute home website received an average of 235 visitors per day, resulting in over 86,000 visitors. Over 70% of these visitors were from the private sector (not from .edu or .gov addresses) and downloaded tools and resources for efficient construction.
 - ♦ To date, the Institute PIER public website had 12,000 page views. Table 8 shows the number of downloads of individual key reports.

Table 8. Downloads from Institute PIER Public Website

# Downloads	Document
5,500	Reanalysis Report: Daylighting in Schools
4,100	Summary of the Reanalysis Report: Daylighting in Schools
3,000	Skylight Photometric Profiles
1,500	Outdoor Lighting Baseline Assessment
300–1,500	Various reports on survey methods, analysis and field findings

Following completion of the final PIER Design Guides and reports, the Institute will do an extensive e-mail PR announcement to a list of interested parties gathered during the course of this research. The list includes over 300 individuals in design, construction and energy efficiency fields, as well as organizations and publications relevant to the design marketplace in California. The Institute plans to maintain the PIER site throughout 2004 in order to have continuity of access to the background, objectives and results of this PIER program. Primary products and reports will continue to be available following that period at our Institute site in support of our sponsors and our nonprofit mission to improve building practices.

Table 9. PIER Articles and Papers

Element/Author	Publication	Date	Market
E2	Testimony to US Senate	Fall 2002	Hearing on High Performance Schools written testimony by Alex Wilson, Building Green, references E2 PIER work.
E2/Heschong	IESNA Journal Daylighting Impacts on Human Performance in Schools	Summer 2002	Lighting industry
	Council of Educational Facilities Planners International Journal Lead article for special sustainable schools edition.	Summer 2002	School facility planners
	ACEEE Summer Study Daylighting and Human Performance	8/02	Energy efficiency & building sciences
	ASHRAE Journal Daylighting and Human Performance	6/02	Lighting industry
	LD&A LightFair Preview Edition	5/02	A&E firms, design and lighting industry
E3/Hydeman	ASHRAE Journal VAV Box Selection	12/03	HVAC designers, engineers and manufacturers
E3/Hydeman & Stein	HPAC Engineering magazine A Fresh Look at Fans	Spring 2003	HVAC vendors and contractors

Element/Author	Publication	Date	Market
E3/Kolderup	ACEEE Summer Study Measured Performance and Design Guidelines for Large Commercial HVAC Systems	8/02	Energy efficiency & building sciences
E3 & E4/ Higgins	Construction Specifier Article referencing PIER research as a basis for the advanced requirements of the “E-Benchmark” (Advanced Building Guideline Criteria)	6/03	Commercial contractors, equipment specifiers, and design/bid firms
E4/CEE	CEE Quarterly Newsletter	9/03	Two articles – one on E4 findings and the other on PIER results helping to form market transformation efforts.
E4/CEE	HECAC Tech Talk ”Refrigerant Charge Control Sparks Interest”	9/03	Distributed to CEE members, manufacturers and other interested stakeholders. Also posted on CEE’s website.
E4/E Source	E Source “2003 Update on Packaged Rooftop Air Conditioners: Are Efficiency Levels Topping Out?”	Fall 2003	HVAC and energy industry References to PIER E4 work in report by Peter Criscione, E Source
E4/Jacobs	Energy Design Resources website Design brief for the integrated design of small commercial HVAC systems	Summer 2003	Small HVAC contractors, specifiers, manufacturers
	HVAC Manufacturers White paper on observed faults and potential solutions, to motivate design changes	8/03	Distributed to HVAC manufacturers in conjunction with CEE mailing on the advanced spec.

Element/Author	Publication	Date	Market
E4/CEE	The Market Transformer Newsletter , “Committee Examines Field Performance of Rooftop Units. On E4’s results and CEE’s efforts to develop an advanced rooftop unit specification.	Spring 2003	Distributed to CEE members, manufacturers and other interested stakeholders. Also posted on CEE’s website.
E4/AirCare Plus	AirCare Plus brochure PIER project results referenced in brochure.	Spring 2003	AirCare Plus is a new pilot premium service program for small RTUs currently being pilot tested by PECI for the Northwest Energy Efficiency Alliance.
E4/Jacobs, Brost & Higgins	National Conference on Building Commissioning Small Commercial Rooftops: Field Problems, Solutions and the Role of Manufacturers	Spring 2003	Paper on PIER E4 findings and recommendations for an advanced specification and HVAC unit.
E4/Jacobs & Institute staff	HPAC Engineering magazine 4 articles on RTU’s: Sizing Small HVAC Economizer failure rates O&M guide Commissioning	8/02 9/02 10/02 11/02	HVAC and building industry
E5/McHugh	NFRC website U-factor and SHGC testing presentation posted on NFRC website	Summer 2003	Window, door and skylight industry
	IESNA Journal Skylights as Luminaires: PIER Skylight Photometric Test Results	Summer 2002	Lighting industry
E6/Hedrick	ASHRAE Systems and Equipment Handbook Provided information that will be included in the 2004 update to the Handbook’s Chapter 9 (duct design).	2004	Building design and construction industry

Element/Author	Publication	Date	Market
	Building Industry Institute (BII) E6's "Guide for Builders" is expected to inform the development of a BII protocol on ducts in conditioned space, with the Guide made available through BII.	2003	Residential designers and builders
	Building America web resources E6 "Home Builders Guide to Duct Placement in Conditioned Space" to be placed as a resource on this national building resource site	Fall 2003	Residential builders and energy efficiency managers
E7/Peet & Brost, & Higgins	ACEEE Summer Study Paper on the PIER California Statewide Outdoor Lighting Baseline Assessment Findings	8/02	Energy efficiency and building sciences
E7/Clanton	Building Standards Magazine "Daylight and Night Darkening"	2/02	Building construction industry
	Lighting.com website (above article)	2/02	Building construction industry

Collaborations & Networking

KEY ACHIEVEMENTS

The project team, as well as the extremely high-caliber professionals who made up their advisory committees, expanded the PIER Program influence through their networking, project steering, and involvement with related projects and industry collaborations. PIER research results are expected to continue to impact the marketplace and future R&D activities well beyond the end of the contract.

The most significant of these collaborations are detailed in Table 10.

Table 10. Significant Collaboration & Networking Activities

Element	Collaborators	Description
All	PIER Program Advisory Committees (PAC)	PAC members represented a wide range of disciplines, including building operation and management, energy research, state building codes, energy research, manufacturing, and utilities. The full PAC convened six times during the course of the program to provide the Element Leaders with suggestions for refining project scopes; input on market needs for the research results; and recommendations for the best strategies to achieve market adoption of the research results.
	Building Operators Certification (BOC) Training Program	The Institute has worked with NEEC, owner and developer of the BOC training that is now used in CA, to incorporate PIER results on E4 into their training modules.
	PIER Element Technical Advisory Groups (TAG)	TAG members included many manufacturer representatives, design professionals, and researchers who are taking PIER information directly to equipment design/production and high-performance building construction venues.
E2	L.A. Unified School District	The Daylighting in Schools reanalysis study contributed to LAUSD's decision to adopt the CHPS guidelines, which will result in improved daylighting in their new schools.

Element	Collaborators	Description
	Rocky Mountain Institute	The Schools Reanalysis results have been incorporated into RMI databases and conference/seminar presentations.
	International Researchers	E2 has responded to inquiries about methodologies and findings from researchers from abroad, including New Zealand, Australia, Singapore, Taiwan, Canada and England.
	Manufacturing Sites	Telephone interviews with the owners of potential candidates for manufacturing study (subsequently cancelled) revealed considerable interest in the study and the effects of daylight.
	Retail Chain Stores	A dozen large national retail chains are known to be building skylit stores or developing prototypes to investigate how skylighting could best be applied to their format. In addition, in 2003 the head of store planning for Federated department stores and seven other major retailers consulted Lisa Hescong for advice on including skylighting in their stores.
	State Agencies	Collaborated with California Department of Health Services and other California agencies in a constellation of studies examining school health outcomes.
E2 & E5	Research Teams	Methodologies and research tools were exchanged with researchers at the Lighting Research Center, LightRight Consortium, Natural Research Canada, the Florida Solar Energy Center, and Lawrence Berkeley National Laboratory.
	Retail Chain Stores	Publicity about HMG's previous retail study and contacts made during E2's PIER research provided access to high-level decision makers in retailer chains for participation in the associated study in E5 on integration of skylights with T-bar ceilings.
	U.S. Department of Energy	Data from E2 and E5 will contribute to the DOE "Roadmap" on daylighting and skylighting design.

Element	Collaborators	Description
E2, E4 & E5	Corporate Management & Realty Corporation	CMRC presents seminars in CA and nationally to facility managers and architects, which now include PIER research information.
E3	Lawrence Berkeley National Laboratory/ UC Berkeley	E3 provided technical data that enhanced LBNL's Duct Research and Fan Diagnostics projects. Also, E3 and LBNL/UCB coordinated data collection for one of the monitored sites, resulting in cost savings for both teams.
	Portland Energy Conservation, Inc. (PECI)	E3, the Institute and PECI held discussions on synergies between E3's Design Guideline and the PECI/LBNL PIER project, "Control System Design Guidelines and Air System Test Guidelines." Discussions resulted in David Sellers of PECI joining E3's TAG.
	Other PIER programs	Collaborated with researchers in LBNL's PIER program, High-Performance Commercial Building Systems (project headed by Tom Webster), studying fan system diagnostics measurement. They installed extra monitoring points needed for E3's analysis; in turn, they used data collected by the E3 team from two sites. Also, a researcher working on another PIER project studying low-energy cooling systems used data from E3's fan research and simulations to improve their fan models.
	U.S. General Services Administration	Through work at a courthouse in Sacramento, E3 influenced operations at federal facilities throughout the region.
	Energy simulation software	An EQuest/DOE2.2 developer has expressed interest in using the fan model in their simulation engine.
E4	Carrier Corp.	Evaluated equipment design and modifications based on E4 findings (details currently proprietary).

Element	Collaborators	Description
	Commissioning Collaboratives	Guideline content from E4 will inform the work of the California Commissioning Collaborative and the Northwest Energy Efficiency Council/ Building Operators Certification Program.
	Portland Energy Conservation Institute	Results from E4 will inform the HVAC Commissioning Guideline revision process and be made available directly to commissioning agents.
	Air-Conditioning and Refrigeration Institute (ARI)	CEE initiated discussions with ARI about the development of a national, next-generation performance specification for small commercial, integrated rooftop HVAC systems (described earlier in the National Programs section). Also, an E4 TAG member who is also an ARI committee chair intends to convene a meeting for the presentation of E4 results.
	Energy Design Resources	There is potential for E4's results to be included in future EDR seminars (not currently scheduled).
	Lighting Software Manufacturers	Some software manufacturers, including Lighting Analysts (producers of AGI-32) and the producers of SkyVision, intend to prepare product revisions that will incorporate PIER photometric results.
E5	Skylight Manufacturers	Several are considering product design modifications. One manufacturer is considering purchasing the photometric test facility. Some manufacturers have purchased further photometric testing by E5's subcontractor.
	Chain Retailer (name confidential)	A large retailer has already used the photometric data to evaluate lighting designs, including skylight and electric lighting integration and vertical illumination on displays.

Element	Collaborators	Description
E6	Research and Construction Industry	Project team worked or was in contact with most of the researchers, consultants and homebuilders who have experience with the issues related to placing ducts in conditioned space, including: Pulte Homes; Steven Winters Associates; Building Science Corporation; Chitwood Energy Management; and National Association of Home Builders Research Center.
	TAG Members	TAG members were active in helping guide the research, and will help promote the findings to the residential homebuilding community. TAG members are Rob Hammon, ConSol Energy Consultants; Daryl Hosler, Southern California Gas; Robert Hemphill, GTI; Marshall Hunt, Pacific Gas & Electric; Iain Walker, Lawrence Berkeley National Laboratory; and Bruce Wilcox, Berkeley Solar Group.
E7	International Dark-Sky Association	PIER results contributed to the outdoor standards in IDA's voluntary national Model Lighting Ordinance.